

CAD Instructor Guide Lesson 12



School's Name
Teacher's Name
Date

What is Sustainable Engineering?

- **Sustainable engineering** is the integration of **social**, **environmental**, and **economic** conditions into a product or process
- Soon all design will be **Sustainable Design**
- **SolidWorks Sustainability** allows students to be environmentally conscious about their designs
- Successful products are developed by integrating **Life Cycle Assessment (LCA)** directly into engineering design process

Life Cycle Assessment - LCA

- A method to quantitatively assess the **environmental impact** of a product throughout its entire lifecycle, from the procurement of the raw materials, through the production, distribution, use, disposal and recycling of that product.



LCA – Life Cycle Assessment

- Raw Material Extraction
 - Planting, growing, and harvesting of trees
 - Mining of raw ore (example: bauxite)
 - Drilling and pumping of oil
- Material Processing - The processing of raw materials into engineered materials
 - Oil into Plastic
 - Iron into Steel
 - Bauxite into Aluminum
- Part Manufacturing - Processing of material into finished parts
 - Injection molding
 - Milling and Turning
 - Casting
 - Stamping
- Assembly – Assemble all of the finished parts to create the final product
- Product Use – End consumer uses product for intended lifespan of product
- End of Life – Once the product reaches the end of its useful life, how is it disposed of
 - Landfill
 - Recycled
 - Incinerated

Life Cycle Assessment Key Elements

- Identify and quantify the environmental loads involved
 - the energy and raw materials consumed
 - the emissions and wastes generated
- Evaluate the potential **environmental impacts** of these loads
- Assess the options available for reducing these **environmental impacts**

Environmental Impact Factors


Carbon Footprint Total Energy



Air Acidification Water Eutrophication

What is Carbon Footprint?


- Carbon Dioxide CO₂ and other gasses which result from the burning of fossil fuels accumulate in the atmosphere which in turn increases the earth's average temperature in kilograms (kg).
- Carbon footprint acts as a proxy for the larger impact factor referred to as Global Warming Potential (GWP).
- Global Warming is responsible for the loss of glaciers, extinction of species, more extreme weather, and other environmental problems.



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What is Total Energy Consumed?


- Measure of the non-renewable energy sources associated with the part's lifecycle in mega joules (MJ). Impact includes:
 - upstream energy required to obtain and process these fuels
 - embodied energy of materials which would be released if burned
 - electricity or fuels used during the product's lifecycle
 - Transportation?
- Efficiencies in energy conversion (e.g. power, heat, steam) are taken into account.



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What is Air Acidification?


- Sulfur Dioxide SO₂, Nitrous Oxides NO_x and other acidic emissions to air that result in acid rain.
- Makes the land and water toxic for plants and aquatic life.
- Slowly dissolves manmade building materials such as concrete.
- Measured in units of kilograms Sulfur Dioxide equivalent (SO₂e)



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What is Water Eutrophication?

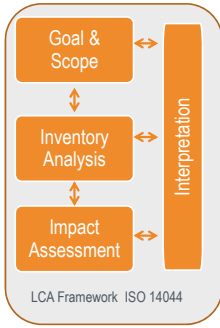
- Over abundance of nutrients added to a water ecosystem.
- Nitrogen (N) and Phosphorous (PO₄) from waste water and agricultural fertilizers cause an overabundance of algae to bloom, which depletes the water of oxygen and results in the death of plant and animal life.
- Measured in kilograms Phosphate equivalent (PO₄e).



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References

- Underlying LCA Technology: PE International
 - 20 years of LCA experience
 - LCA international database
 - GaBi 4 - leading software application for product sustainability
 - www.pe-international.com
- International LCA Standards
 - Environmental Management Life Cycle Assessment Principles and Framework ISO 14040/44 www.iso.org
- US EPA LCA Resources
 - <http://www.epa.gov/nrmrl/lcaccess/>



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Why SolidWorks Sustainability?

Soon all design will be Sustainable Design

- More consumers want "greener" products
- New and unfamiliar challenge for businesses
- Sustainable design is a strategy for success
- SolidWorks Sustainability
 - Easy to use and to understand
 - Reduces the environmental impact of product designs
 - Communicates effectively through reports and graphic display
 - SolidWorks SustainabilityXpress¹ is available to EVERY SolidWorks user at no cost

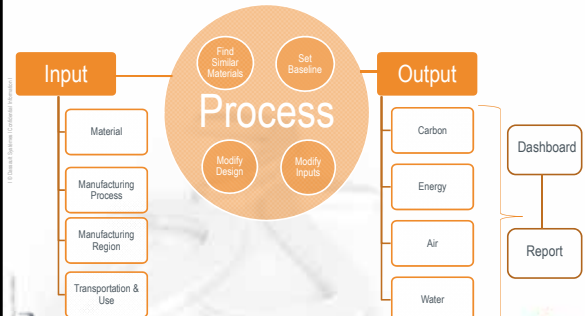
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Why SolidWorks Sustainability in the classroom?



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SolidWorks Sustainability Methodology



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Input Material Class and Material Name

Material Class and Name Hierarchy

Material Class		Material Name Material Class: Plastics	
Steel	Plastics	ABS PC	Acrylonitrile Butadiene Styrene Polycarbonate
Iron	Other Metals	Acrylic	
Aluminum Alloys	Other non-metals	Delrin® 2700 NC010	Polyoxymethylene (POM, polyacetal or polyformaldehyde) mfg by Dupont
Copper Alloys	Generic Glass Fibers	Nylon 101	
Titanium Alloys	Carbon Fibers	PE High Density	Polyethylene
Zinc Alloys	Silicons	PVC Rigid	Polyvinyl Chloride
Other Alloys	Woods	And many more	

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Input Manufacturing Process

Available manufacturing depends on material class

Manufacturing Process	Class: Aluminum Alloys		Manufacturing Process	Class: Plastics	
	Die Casted	Sand Casted		Injection Molded	
	Extrusion	Stamped/ Formed Sheet Metal		Extrusion	
	Forged	Machined Sand Casted			
	Milled	Turned			

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Input Manufacturing Region

- Each region produces energy by different method combinations. Impact of a kWh is different for each region. Example methods include:
 - Fossil Fuels
 - Nuclear
 - Hydro-electric
- Determines the resources consumed by manufacturing processes in that region
- Region Choices
 - Asia
 - Europe
 - North America
 - Japan



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Input Transportation and Use Region

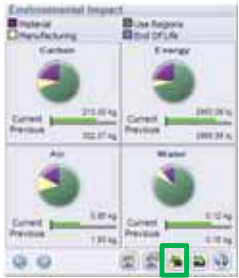
- Determines the energy sources consumed during the product's use phase (if applicable) and the destination for the product at its end-of-life.
 - Asia
 - Europe
 - North America
 - Japan
- Estimates the environmental impacts associated with transporting the product from its manufacturing location to its use location.



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SolidWorks Calculates Environmental Impact

- Parameters
 - Carbon Footprint
 - Air Acidification
 - Water Eutrophication
 - Energy Consumed
- Factor Percentage
 - Material
 - Manufacturing
 - Use Regions
 - End of Life
- Set Baseline



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Find Similar Materials based on Material Properties

- Thermal Expansion
- Specific Heat
- Density
- Elastic Modulus
- Shear Modulus
- Thermal Conductivity
- Poisson's Ratio
- Tensile Strength
- Yield Strength



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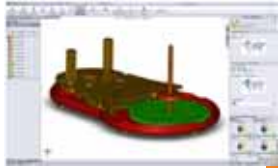
Definitions of Material Properties

- Thermal Expansion - the change in length per unit length per one degree change in temperature (change in normal strain per unit temperature) (K)
- Specific Heat - quantity of heat needed to raise the temperature of a unit mass of the material by one degree of temperature. (J/kg K)
- Density - Mass per unit volume. (kg/m³)
- Elastic Modulus (Young's Modulus) - ratio between the stress and the associated strain in a specified direction (N/m²)
- Shear Modulus (Modulus of Rigidity) - the ratio between the shearing stress in a plane divided by the associated shearing strain (N/m²)
- Thermal Conductivity - rate of heat transfer through a unit thickness of the material per unit temperature difference. (W/m K)
- Poisson's Ratio - ratio between the contraction (transverse strain), normal to the applied load to the extension (axial strain), in the direction of the applied load. Poisson's ratio is a dimensionless quantity.
- Tensile Strength - the maximum amount of tensile stress that a material can be subjected to before failure (N/m²)
- Yield Strength - Stress at which the material becomes permanently deformed (N/m²)

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SolidWorks Sustainability

- Same functions as SustainabilityXpress
- LCA of assemblies
- Configuration support
 - Save inputs and results per configuration
- Expanded reporting capabilities for assemblies
- Specify amount & type of energy consumed during use
- Specify method of transportation
- Support for Assembly Visualization



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Sustainable Report



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SolidWorks Sustainability - Online Calculator

Converts environmental impacts into human scale parameters
Example: Carbon Footprint converted into miles driven in a car



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Why SolidWorks Sustainability in the classroom?

- **Students need** to learn, understand, improve, and communicate the environmental impact of their design
- **Educators can** provide insights on how choices in material and manufacturing processes affect the environment
- **Instruction combines** design and technology with the social, environmental, and economic conditions

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